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Choosing a Bt Transgenic Corn Hybrid

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Seed corn companies are offering a variety of corn hybrids that have been engineered (transformed) to produce a version of the insecticidal protein (Cry-protein) from the naturally occurring soil bacterium, *Bacillus thuringiensis* (Bt). Bt also is used as a formulated insecticide (Dipel, M-Peril, etc.) against European corn borer (ECB) larvae. These Bt-transgenic corn hybrids offer a degree of control of European corn borer larvae that is far greater than that of native resistance previously available in corn hybrids, and equal to or greater than that of conventional insecticide applications. This publication discusses some factors that growers should evaluate as they choose whether to adopt this technology.

The successful insertion of the gene encoding the insecticidal protein into the corn plant DNA is referred to as an "event". Currently, five events have been registered by the Environmental Protection Agency *(Table I)* and are trademarked as Yieldgard™, Knock*Out*™, NaturGard™, Bt-Xtra™, and Starlink™. Other events are likely to be registered and commercialized soon.

The different events vary in the type of protein produced or the expression of the protein. Expression refers to where and at what plant stages the Bt protein is produced in the corn plant. This difference in expression results in differences in effectiveness against corn borer larvae (see *Table I*). The event in Knock*Out*™ and NaturGard™ is referred to as "event 176" and the Bt protein is expressed only in green tissue and pollen**.** Based on University field studies, efficacy of this event against whorl feeding or first generation larvae is excellent (95 percent or more reduction) and comparable to hybrids containing other events. Efficacy of this event against second generation larvae that attack corn during grain fill may be reduced due to lack of expression in the silk and developing ear and the decreasing Bt protein production that occurs as the plant senesces. The event in Bt-Xtra™ is referred to as DBT-418 and expresses the Bt protein throughout the entire plant. Efficacy of this event against first generation larvae is excellent; however, efficacy against the second generation is reduced because of declining Bt protein production after pollen shed. The events in Yieldgard™ , Bt11 and Mon810, and the Starlink™ , CBH-351, also express the Bt protein throughout the entire plant. Based on University field studies, these events provide excellent control (95 percent or more reduction) of both European corn borer generations throughout the season.

A key issue surrounding acceptance, registration, and use of Bt corn is resistance management. European corn borer larvae likely will become resistant to Bt corn if appropriate resistance management strategies are not adopted. Corn borer larvae feeding on Bt corn are exposed to the Bt toxin at much higher levels than from use of foliar Bt insecticides. Also, corn borer larvae feeding on Bt corn are exposed to Bt toxin for a much longer time. Under this high level of selection pressure, the potential threat of resistance necessitates the implementation of management plans to prevent or at least delay the development of resistance. Based on current knowledge of European corn borer biology and pesticide resistance, computer simulation models have been used to help design resistance management strategies.

An important principle of resistance management plans for European corn borer and Bt corn is the use of refuges. A refuge is any European corn borer host plant (non-Bt corn, potatoes, oats, sorghum, and some weeds) not producing Bt proteins or being treated with conventional Bt formulations. In current resistance management plans the refuge must be non-Bt corn. The purpose of the refuge is to supply a source of Bt-susceptible European corn borer that could mate with resistant European corn borer potentially emerging from nearby Bt corn. These matings will in effect dilute resistance that may develop. Computer simulation models suggest that approximately 20-30 percent of the local European corn borer population in any year should not be exposed to Bt corn. As a condition of EPA registration, industry registrants are required to develop resistance management plans to be

Table I. Characteristics of commercial products developed form various Bt events.

Bt Event	*Commercial Source*	*Expression*	*Efficacy*
E-176	Knock*Out*™ (Novartis Seeds), NaturGard™ (Mycogen Seeds)	Insecticidal protein (Cry1Ab) expressed in green tissue and pollen.	High degree of control of 1st generation ECB; control of 2nd generation ECB decreases as plant senesces; some suppression of corn earworm, southwestern corn borer, and southern cornstalk borer.
Bt-11	Yieldgard™ (Novartis Seeds)	Insecticidal protein (Cry1Ab) expressed throughout the entire plant.	High degree of control of 1st and 2nd generation ECB; some suppression of corn earworm, fall armyworm, southwestern corn borer, and southern cornstalk borer.
Mon-810	Yieldgard™ (Monsanto) marketed by Cargill, Golden Harvest, Pioneer, DeKalb and others	Insecticidal protein (Cry1Ab) expressed throughout the entire plant.	High degree of control of 1st and 2nd generation ECB; some suppression of corn earworm, fall armyworm, southwestern corn borer, and southern cornstalk borer.
DBT-418	Bt-Xtra™ (DeKalb)	Insecticidal protein (Cry1Ac) expressed throughout the entire plant.	High degree of control of 1st generation ECB; some suppression of southwestern corn borer, and southern cornstalk borer.
CBH-351	StarLink™ (AgrEvo) marketed by Garst and others	Insecticidal protein (Cry9C) expressed throughout the entire plant.	High degree of control of 1st and 2nd generation ECB; some suppression of black cutworm, southwestern corn borer, and southern cornstalk borer.

implemented by producers. Specific resistance management information will be included on the label of each corn seed bag. **Be sure to discuss resistance management strategies with your seed dealer before buying seed**.

Another aspect of Bt corn production relates to acceptance of Bt corn in foreign and domestic grain markets. Information on this is constantly changing. Learn about current developments and consult with your seed dealer and grain handler (local elevator) to incorporate this information into your hybrid selection process. When selecting seed, consider separation of Bt and non-Bt grain, processor marketing plans, approval status of Bt corn hybrids, and possible premiums for non-Bt corn. Several sources listed at the end of this publication provide current news and information on marketing Bt corn.

Some Considerations About Selection And Use Of Bt Corn Hybrids

- Current Bt corn hybrids protect against damage by European corn borer larvae and some events suppress a few other lepidopteran corn pests (see *Table I*). All other common corn pests, such as western bean cutworm, corn rootworm, and spider mites are not affected and may require insecticide treatment.
- Events differ in their efficacy against European corn borer larvae. Some are less effective against second generation European corn borer larvae (see *Table I*).
- Research has shown that the Bt transformation event **does not** change the genetic yield potential of the hybrid. The event only protects the hybrid from European corn borer damage. The best yielding hybrid for your farm may or may not be a Bt hybrid.
- Economic infestations of European corn borer do not occur every year. You pay an added fee for the Bt corn whether you have economic European corn borer infestations or not. Compare the total cost of Bt corn seed with the cost of your annual yield loss caused by European corn borer and the cost of conventional insecticide applications to control economic infestations. Refer to UNL Extension publications or the UNL Entomology Web site listed in '**Additional Sources of Information'** for methods to estimate economic gain or loss.
- Consider the cost to control other corn pests not controlled by Bt corn (e.g. corn rootworm beetles, spider mites, grasshoppers, and western bean cutworm).
- Pay special attention to information about resistance management and insect damage monitoring. Remember, you are required to plant a percentage of your corn acres in non-Bt corn to act as a refuge. Specifics for refuge planting and placement will accompany the Bt seed corn label and/or grower agreement.
- Make a permanent annual record of where Bt transgenic hybrids are planted. This will aid in verifying performance and monitoring resistance.

- To provide more information when deciding whether to plant Bt corn hybrids, collect information annually on the degree of European corn borer damage in all cornfields. Build this information over several years and correlate it with location, corn hybrid, planting date, insecticide use, etc.
- Consult with your seed dealer and grain handler (local elevator) on marketing aspects of Bt corn. Should you keep Bt corn and non-Bt grain separate? Will premiums be paid for non-Bt corn?

Additional Sources of Information

UNL Entomology Department Web site: *http://www.ianr. unl.edu/ianr/entomol/entdept.htm* This site provides information on European corn borer biology, ecology, and management in Nebraska. It also provides links to other Web sites of interest.

National Corn Growers Association Web site: *http://www.ncga.com* This site provides news and information on a variety of topics of interest to corn producers, including processor marketing plans, approval status of Bt corn hybrids, and guidelines for Bt corn producers.

American Seed Trade Association Web site: *http://www.amseed.com* This site provides a searchable database of grain handlers that accept non-European Union approved grain, as well as various links to other Web sites of interest.

Bt Corn and European Corn Borer: Long-Term Success Through Resistance Management. 1997. K. R. Ostlie, W. D. Hutchinson & R. L. Hellmich (eds.). North Central Regional Extension Publication NCR 602. University of Minnesota, St. Paul, MN. This 17-page guide on Bt corn and resistance management is available from your local Cooperative Extension Office.

An Evaluation of Insect Resistance Management in Bt Field Corn: A Science-Based Framework For Risk Assessment and Risk Management. Report of an Expert Panel. 1999. International Life Sciences Institute, Health and Environmental Sciences Institute. Washington, D.C. This 78-page document can be viewed at *http://www.ilsi.org/reports.htm*.

The European Corn Borer: Biology and Management. 1997. J. F. Witkowski and R. J. Wright. This is a NebGuide on basic European corn borer biology and management in Nebraska and can be obtained through your local Cooperative Extension Office. It does not address Bt corn. An enhanced version can be found on the Web at *http://www.ianr.unl.edu/ianr/entomol/ecb/ecb1.htm*.

European Corn Borer Ecology and Management. 1996. C. E. Mason et al. North Central Regional Extension Publication 327. Iowa State University, Ames. This is a 57-page guide on European corn borer ecology and management in the north central United States (Kansas to North Dakota, Nebraska to Ohio) and can be obtained from your local Cooperative Extension Office. It does not address Bt corn.

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